A NEW SPECIES OF TORRENT-DWELLING FROG (ANURA: HYLIDAE: *LITORIA*) FROM THE MOUNTAINS OF INDONESIAN NEW GUINEA (WEST PAPUA)

STEPHEN J. RICHARDS

Richards, S.J. 2001 06 30: A new species of torrent-dwelling frog (Anura: Hylidae: *Litoria*) from the mountains of Indonesian New Guinea (West Papua). *Memoirs of the Queensland Museum* **46**(2): 733-739. Brisbane. ISSN 0079-8835.

Litoria macki sp. nov. from the mountains of West Papua, Indonesia, is a torrent-dwelling species characterised by medium size (adult ♂♂ 42.1-45.7mm SVL), unwebbed fingers, and prominent conical tubercles on the dorsum and limbs. The new species most closely resembles *L. spinifera* (Tyler), from which it can be distinguished by its larger size and different advertisement call. The calls of *L. macki* and *L. spinifera* are described and compared, and natural history observations on *L. spinifera* are presented. ❐ *Torrent-dwelling frog, West Papua, new species.*

Stephen Richards, School of Tropical Biology, James Cook University, Townsville 4811 (present address, Vertebrate Department, South Australian Museum, North Terrace, Adelaide 5000); 11 August 2000.

Torrent-dwelling hylid frogs within *Litoria* are a diverse assemblage reaching their greatest diversity in the mountains of New Guinea. All species for which life history features are documented lay unpigmented, macroleeithal eggs and have tadpoles with dorsoventrally flattened bodies and large, ventral suetorial mouthparts (Haas & Richards, 1998; Tyler & Davies, 1978). The *L. becki* species-group (Tyler & Davies, 1978) contains 5 predominantly montane torrent-dwelling frogs (*L. becki*, *L. micromembrana*, *L. modica*, *L. pratti* and *L. spinifera*) from mountains of New Guinea. These species are most easily distinguished from other torrent-dwelling *Litoria* by their medium size (♂♂ and ♀♀ to about 42mm and 53mm, respectively) and long, unwebbed fingers (Tyler & Davies, 1978).

Litoria spinifera (Tyler, 1968) is distinctive within the *L. becki* group with a sharply pointed snout and greatly enlarged tubercles on the dorsum, eyelids, tarsus and foot (Tyler, 1968). It was described from a large series of frogs collected by Mr Fred Parker at altitudes of 1000 - 1500m in dense rainforest S of Kundiawa in the central mountains of PNG (Tyler, 1968). The type series was collected 'in the vicinity of small waterways', where they were found among leaves near the streams during the day and on leaves overhanging the water at night (Tyler, 1968). Nothing else is known about its biology. During 1997 and 1998, I recorded its advertisement call and made observations on its general natural history in the Crater Mountain Wildlife Management Area (CMWMA), in Eastern Highlands Province, PNG.

Conservation International's 1998 biodiversity survey of the rugged Wapoga River headwaters region of West Papua (Mack & Alonso, 2000) accumulated a significant collection of torrent-dwelling hylid frogs (Richards, S.J., Iskandar, D. & Allison, A. in Mack & Alonso, 2000:54-57). Among these is an undescribed *Litoria* that resembles *L. spinifera* in its possession of large conical tubercles on the dorsum and limbs, but differs from that species in its larger size and different advertisement call.

In this paper I describe the new species from West Papua, and analyse and compare its vocalisations with those of *L. spinifera*. I also present brief observations on the natural history of *L. spinifera* in the CMWMA.

MATERIALS AND METHODS

Specimens are deposited in the Museum Zoologie Bogor (MZB), Indonesia, the Queensland Museum (QM), Australia, and the South Australian Museum (SAMA), Australia. Measurements (to the nearest 0.1mm) were taken with dial callipers and a stereomicroscope fitted with an ocular micrometer, and follow Menzies (1993). They are: SVL (snout-vent length), TL (tibia length), HW (head width at tympanum), HL (head length from tip of snout to posterior edge of tympanum), EYE (horizontal eye diameter), TYM (horizontal tympanum diameter), IN (inter-narial distance), EN (distance between anterior edge of eye and posterior edge of naris), 3FD (width of 3rd finger disc at right angle to digital axis) and 3FP (width of penultimate

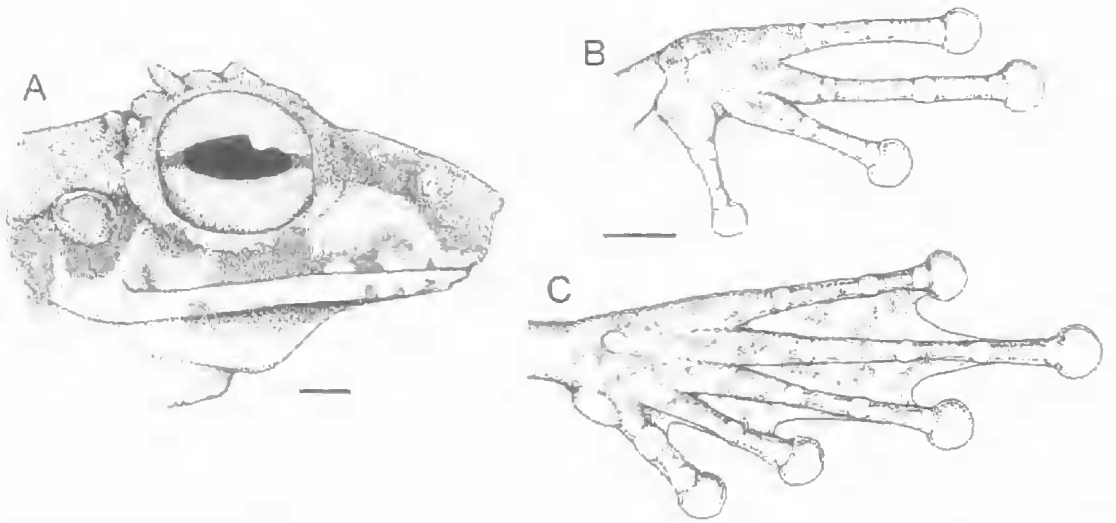

FIG. 1. *Litoria macki* sp. nov. (QMJ75810). A, lateral view of head; B, palmar view of hand; C, plantar view of foot. Scale bars = 2mm.

phalanx of 3rd finger), 4TD and 4TP (4th toe disc and 4th toe phalanx, as for 3rd finger).

Calls were recorded with a Sony Professional Walkman tape recorder and Sony SMZ-200 microphone, and were analysed with the sound analysis program Avisoft SAS-Lab Pro. Note structure was highly variable, both within and between call sequences and individual males. Variation involved the degree of pulse definition, and the presence or absence of minor pulses in terminal portions of the note. In an attempt to attain consistency only well defined pulses and pulses that contributed substantial energy to the note, were calculated for comparisons among species.

SYSTEMATICS

Litoria macki sp. nov.
(Figs 1-6)

ETYMOLOGY. Named for Dr Andy Mack in appreciation of his unfailing encouragement and support and in recognition of his passion for conservation and science education in New Guinea.

MATERIAL. HOLOTYPE: MZB Amp.3870, adult ♂, collected by S.J. Richards and M. Moore, Wapoga Alpha mineral exploration camp, West Papua, Indonesia, 3°08.687'S, 136°34.423'E, 1070m, 17.iv.98. PARATYPES: MZB Amp.3871, 3872, QM J75810, SAMA R55363 same collection data as holotype, SAMA R55364 collected by M. Moore at Lagori Landing Site 21 (LS-21), West Papua, Indonesia, 3°00.348'S, 136°33.412'E, 275m, 26.iv.98.

DIAGNOSIS. A medium-sized *Litoria*, ♂♂ 42.1-45.7mm SVL, distinguished from all known New Guinea species except *L. spinifera* by the combination of: 1, blotched green and brown dorsally in life; 2, canthus rostralis well-defined, moderately curved; 3, fingers long, unwebbed; 4, large conical tubercles on tarsus and foot, and on dorsum (concentrated on head and eyelids). Distinguished from *L. spinifera* by its larger size (SVL of male *L. spinifera* 35.3-42.3) and different advertisement call, which consists of a rapidly-repeated series of loud, bell-like notes in which note repetition rate, note length, and pulses/note increase during the call sequence.

DESCRIPTION OF HOLOTYPE. An adult ♂ measuring: SVL 45.7; TL 29.0; HW 15.6; HL 16; EYE 5.5; EN 4.0; IN 5.1; TYM 2.0; 3rd finger 1.2; 3rd disc 2.9; 4th toe 1.2; 4th disc 2.5. Body slender, limbs long (TL/SVL 0.634). Head slightly longer than broad (HL/HW 1.04), more than one third of snout-vent length (HL/SVL 0.35); snout slightly pointed in dorsal view, pointed in lateral view, projecting slightly beyond lower jaw. Canthus rostralis well-defined, moderately curved, loreal region strongly concave. Nostrils close to tip of snout, internarial distance greater than distance between snout and naris (EN/IN 0.784). Eyes large, prominent (EYE/SVL 0.12), pupil horizontal, eyelid without reticulations. Vomerine teeth in two prominent oblique ridges between the choanae, vocal slits present. Tongue cordiform. Tympanum clearly visible, but dorsal edge obscured by prominent, slightly curved supratympanic fold. Fingers long, unwebbed,

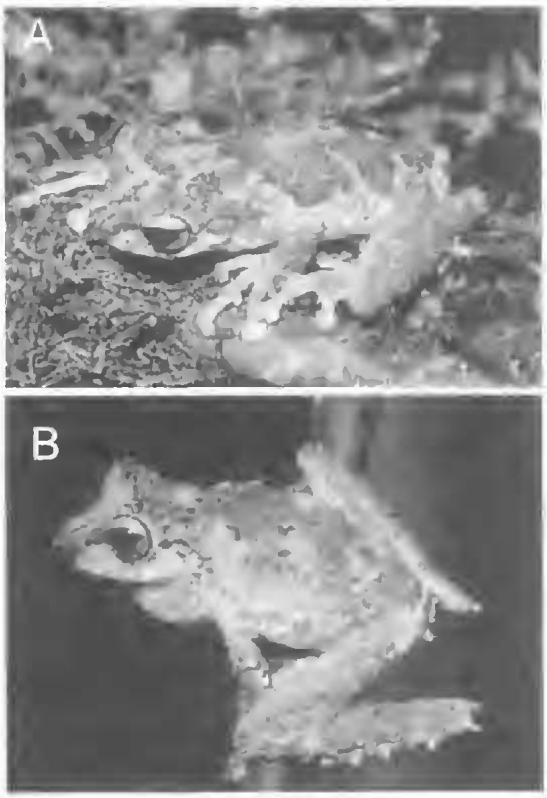

FIG. 2. A, adult *Litoria macki* sp. nov. from Wapoga River headwaters, West Papua. B, adult *L. spinifera* from Maimafu, Eastern Highlands Province, PNG.

relative lengths 3>4>2>1, terminal discs large (3FP/3FD 0.41); A brown nuptial rugosity on first finger extends distally to level of penultimate tubercle. Toes 2/3 webbed, web reaching to just below penultimate tubercle on 4th toe, and nearly to disc on toes 2, 3 and 5, relative lengths 4>5=3>2>1, terminal discs large (4TP/4TD 0.48). Conical tubercles on limbs (including heel) and dorsum, concentrated on head and eyelids, and on outer edge of tarsus and foot.

In life, mottled with large patches of brown and green dorsally, including dorsal surfaces of legs. Yellow in groin and axilla. Laterally pale yellow grading to white anteriorly and ventrally. Venter white, mottled with faint brown pigmentation. Iris gold with purple reticulations. Tubercles beneath vent white. In preservative brown dorsally, with extensive blue (green in life) patches. Pale yellow lateral and inguinal regions have faded to white.

VARIATION. The paratypes are adult males (SVL 42.1-45.3) and the colour pattern is uniform in the type series: in life all were blotched with brown and green dorsally. The size and distribution of tubercles on the dorsum and legs are variable but in all specimens tubercles on the eyelids, tarsus and heel are prominent. Measurements are summarised and compared with *C. spinifera* in Table 1.

ADVERTISEMENT CALL. The advertisement call is a series of 14-44 bell-like notes lasting about 7-50 seconds. Dominant frequency is 2606-3144Hz. A consistent and distinctive feature of the call is an increase in note repetition rate and pulses/note in terminal sequences (Fig. 5; Table 2). Individual notes are about 0.02s in length at the beginning of a call sequence and contain a single pulse. During the call sequence note length increases to 0.04-0.06s and the number of pulses/note increases to 6-8. A call sequence is illustrated in Fig. 5 and structural features are summarised in Table 2.

FIG. 3. Torrential stream habitat of *L. macki* in lower montane rainforest, West Papua.

TABLE 1. Morphological comparison of ♂ types of *Litoria macki* sp. nov. and ♂ *L. spinifera* (Tyler). Measurements involving finger and toe discs only recorded where discs are well-preserved.

	Litoria macki (n = 6)		*Litoria spinifera* (n = 8) CMWMA (see text)		*Litoria spinifera* (n = 12) from vicinity of type locality	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
SVL	43.93 (1.36)	42.1-45.7	38.98 (1.42)	37.4-41.4	37.26 (1.29)	35.3-39.4
TL/SVL	0.629 (0.016)	0.604-0.650	0.632 (0.017)	0.609-0.658	0.657 (0.020)	0.630-0.691
EYE/SVL	0.125 (0.009)	0.114-0.142	0.130 (0.003)	0.126-0.135	0.116 (0.009)	0.107-0.137
EN/IN	0.664 (0.075)	0.592-0.784	0.630 (0.032)	0.592-0.680	0.698 (0.052)	0.615-0.829
HW/SVL	0.340 (0.005)	0.335-0.349	0.348 (0.005)	0.341-0.355	0.352 (0.010)	0.337-0.371
3FP/3FD	0.402 (0.029)	0.370-0.448	0.456 (0.036)	0.416-0.500	0.449 (0.022)	0.409-0.476
4TP/4TD	0.503 (0.015)	0.480-0.520	0.567 (0.058)	0.523-0.666	0.512 (0.032)	0.473-0.588
3FD/SVL	0.064 (0.004)	0.061-0.073	0.057 (0.002)	0.053-0.059	0.058 (0.002)	0.053-0.061
4TD/SVL	0.055 (0.005)	0.050-0.064	0.051 (0.002)	0.048-0.054	0.050 (0.003)	0.047-0.059

NATURAL HISTORY. Males called at night from small trees adjacent to and hanging over small (<5m wide) torrential streams in closed-canopy rainforest (Fig. 3). They were never observed in swampy or slow-flowing aquatic habitats. Perch sites were high above or adjacent to the water, normally exceeding 2m high, but two frogs were observed on perches about 1m above the water. Several species of suctorial tadpoles were observed in streams occupied by this species, but it is not possible to associate any of these with the new species.

DISTRIBUTION. Known only from 2 localities in the mountainous headwaters region of the Wapoga River in NW West Papua, Indonesian New Guinea (Fig. 4).

COMPARISON WITH OTHER SPECIES AND DISCUSSION. Lack of webbing between the fingers and presence of prominent conical tubercles on the dorsum and limbs will distinguish *L. macki* from all New Guinea *Litoria* except *L. spinifera*. I have examined 7 paratypes (SAMA R6295-6301) and 5 additional specimens (SAMA R9167, SAMA R9108A-D) of *Litoria spinifera* collected in the vicinity of the type locality, and compared them with 8 specimens (SAMA R55357-62; UPNG 9963-4) from the Crater Mountain Wildlife Management Area (55-75km SE of Kundiawa). The frogs from CMWMA have prominent tubercles along the edge of the tarsus and foot (Fig. 2) and agree in all other respects except minimum adult size with the type series (Table 1). The minimum SVL reported for the type series is 38.4mm (Tyler 1968) but the minimum for frogs from CMWMA is 36.7mm. However re-measurement of the seven *L. spinifera* paratypes shows that six specimens have an SVL less than 38.4mm and the minimum SVL of this sample is 35.5mm. The smallest adult male *L. spinifera* that I have examined has an SVL of 35.3mm and the mean SVL of frogs from the vicinity of the type locality and from CMWMA are 37.26 and 38.98mm respectively (Table 1). There is therefore complete overlap between the type series and specimens from the CMWMA in all characters examined and I have no hesitation in referring the CMWMA specimens to this species.

In contrast there is no overlap in size between the type series of *L. macki* and the eight *L. spinifera* from the CMWMA (SVL 42.1-45.3 vs 36.7-41.4 in *spinifera*; Table 1), and only marginal overlap between *L. macki* and the large type series of *L. spinifera* (29 males from Oruge and vicinity measuring 35.5-42.3mm; upper size limit based on Tyler, 1968) (Table 1). Size of finger discs is another character that is useful for distinguishing between these two species. The disc of the third finger is larger in proportion to SVL in *L. macki* than in *L. spinifera* (3FD/SVL 0.061-0.073 vs 0.053-0.061; Table 1). Only one of the *L. spinifera* examined had a 3FD/SVL ratio that was as large as the smallest ratio recorded for *L. macki*.

Difference in size alone would be insufficient to warrant recognition of the Wapoga specimens and *L. spinifera* as distinct taxa, given that the populations are allopatric and separated by nearly 1000km (Fig. 4). However *L. macki* can be further distinguished from *L. spinifera* by its advertisement call, which is a short sequence of 14-44 explosive notes (see above). In contrast the calls of *L. spinifera* are distinctly pulsed musical notes uttered singly at regular or irregular intervals of 1.5-8 seconds (Fig. 5). The call of *L.*

TABLE 2. Advertisement call characteristics of *Litoria macki* sp. nov. and *L. spinifera* (Tyler). [1] structural features of notes based on two call series only, [2] only a short portion of a much longer sequence was recorded, [3] exeluding territorial calls. Data are presented as mean (SD) range.

	Litoria macki		*Litoria spinifera*	
Frog number (call sequences)	QM J75810 (n = 3)[1]	SAMA R 55363 (n = 3)	Herowana SAMA R55361 (n = 1)[2]	Maimafu SAMA R55357 (n = 2)
Date	17.iv.98	17.iv.98	3.xii.98	1.xii.97
Snout-vent length (mm)	42.1	43.7	41.4	39.5
Temperature °C	20.8	22.5	20.6	20
Full call sequence				
Total notes in sequence	18-44	14-19	6	25-49
Call duration (s)	10.3-48.7	7.2-15.4	22.75	97.2-125.3
Note repetition rate (notes/s)	0.9-1.66	1.22-1.82	0.22	0.25-0.39
Note duration (s)[3]	0.04 (0.01) 0.015-0.084	0.03 (0.01) 0.015-0.066)	0.025 (0.009) 0.019-0.045)	0.03 (0.01) 0.013-0.095
Pulses per note[3]	3.2 (2.4) 1-9	3.0 (2.0) 1-8	3.5 (1.22) 3-6	4.04 (1.5) 2-9
Single-pulse notes?	Yes	Yes	No	No
Dominant frequency (Hz)	2606-2842	2961-3144	2885-3015	1335-2821
Introductory notes				
Note repetition rate (notes/s)	0.78-1.16	0.84-0.92	-	-
Terminal notes				
Note repetition rate (notes/s)	1.9-2.39	2.56-2.57	-	-
Territorial calls				
Type 1 (n = 6) Length (s)	-	-	-	0.358 (0.09) 0.21-0.44
Number of pulses	-	-	-	34.83 (9.5) 19-44
Type 2 (n = 4) Number of notes per sequenee	-	-	-	5-6
Note repetition rate (notes/s)	-	-	-	2.24 (0.32) 2.0-2.7

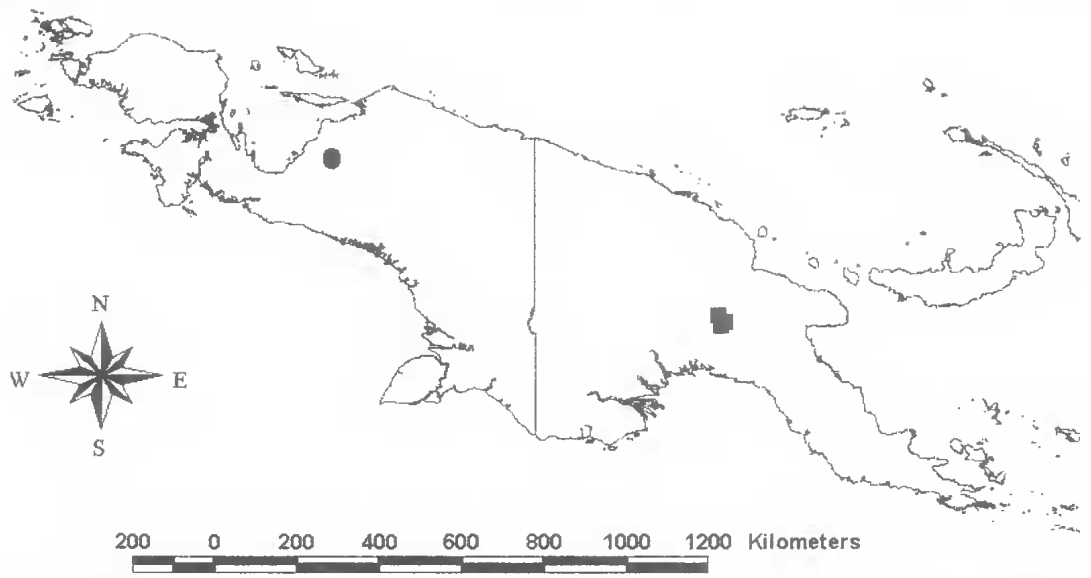

FIG. 4. Distribution of *L. macki* (●) and *L. spinifera* (■: Crater Mountain sites only) specimens examined during this study.

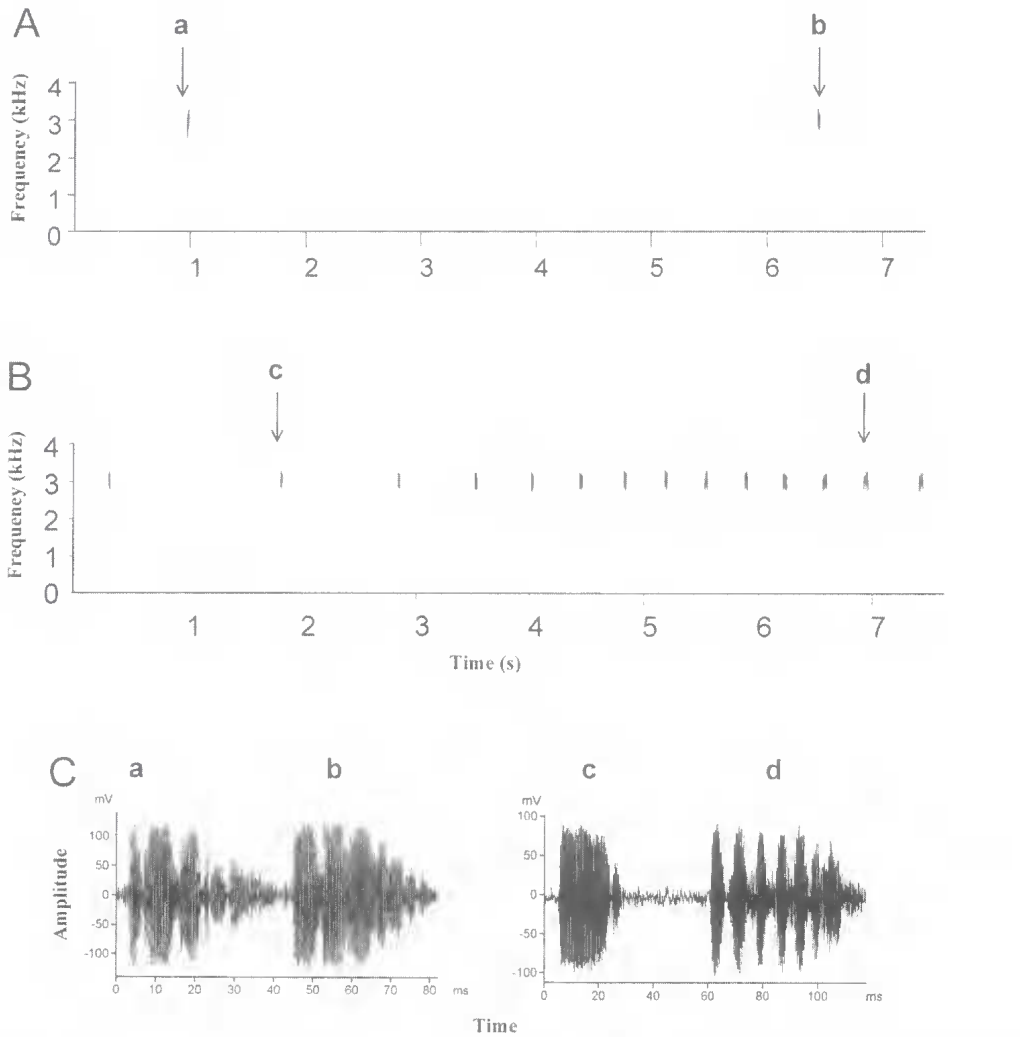

FIG. 5. Advertisement calls of A, *Litoria spinifera* (SAMA R55361) from Herowana, PNG, two consecutive notes from a long series at an air temperature of 20.6 °C; B, *Litoria macki* (SAMA R55363) at an air temperature of 22.5°C, audiospectrogram of full call sequence showing increasing note repetition rate during call sequence; C, wave forms of notes indicated, showing distinctly pulsed calls of *L. spinifera* and change in pulse number during call sequence of *L. macki*.

spinifera also differs from that of *L. macki* in the following features: in *L. spinifera* all notes are distinctly pulsed (vs single-pulse introductory notes in *L. macki*; Table 2), note repetition rate is much slower than that of *L. macki* at similar temperatures, and note repetition rate and pulses/note do not increase dramatically during a sequence of calls. The call of *L. spinifera* is described in more detail below and structural features are presented and compared with *L. macki* in Table 2.

DISTRIBUTION AND NATURAL HISTORY OF *LITORIA SPINIFERA*

Litoria spinifera was previously known from several localities SW of Gumine in Chimbu Province. Although precise coordinates are not available, all of these sites are clustered in an area extending from approximately 6°12'S, 144°57'E in the north to approximately 6°43'S, 144°43'E in the south. *L. spinifera* was a common species in the Crater Mountain Wildlife Management Area (Herowana 6°39'14.5"S, 145°11'49.8"E; Maimafu 6°30'06.0"S, 145°01'59.1"E) during

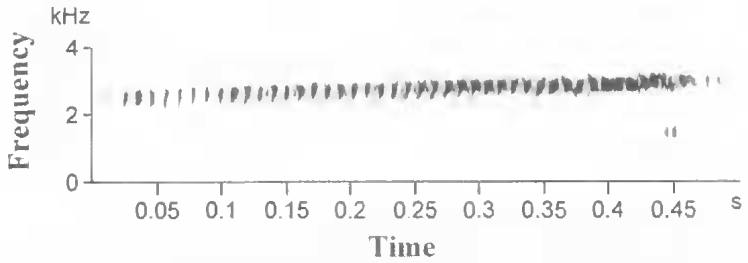

FIG. 6. 'Territorial' call of *Litoria spinifera* from Maimafu, given during vocal interaction with another calling frog.

November-December 1997 and 1998, and in January 2000 adults were heard calling, and several immature specimens were observed, at the Wara Sera Research Station (6°43.423'S, 145°05.693'E) (Fig. 4). The CMWMA records extend the known distribution of this species about 40km to the east.

At Herowana and Maimafu males called from leaves one to 3 metres above the ground, above or adjacent to small torrential streams. At Herowana males were common along streams running through disturbed rainforest and old gardens, suggesting that this species is tolerant of significant human disturbance. Some of these streams had beds that were heavily silted due to erosion from the surrounding denuded hill slopes.

ADVERTISEMENT CALL OF *LITORIA SPINIFERA*. The advertisement call of *L. spinifera* is a single distinctly pulsed note. Each note consists of 2-9 pulses (Fig. 6; Table 2), and notes are repeated at intervals of about 1.5-8 seconds for very long periods. Two complete call sequences recorded at Maimafu lasted for 97.2 seconds and 125.3 seconds (Table 2). Two other call-types, tentatively identified as territorial calls, were heard but were much less common and only produced by one male in response to calls of a nearby conspecific. Territorial call type 1 consisted of a single drawn out note with substantially more pulses than 'normal' calls (Table 2). Territorial call type 2 involved the production of 5-6 notes in rapid succession, with a repetition rate substantially higher than that of the whole call sequence (Table 2). Both of these territorial call types were uttered intermittently during long sequences of 'normal' (advertisement) calls.

All calls are finely tuned, with energy concentrated in narrow bands giving them a musical quality. In calls from Herowana, energy is concentrated in a single band, but in calls from Maimafu energy is concentrated in 2 distinct, harmonically related bands. In some notes the lower frequency is dominant; in others the higher frequency dominates.

ACKNOWLEDGEMENTS

I am extremely grateful to Dr Arie Budiman of Puslitbang Zoology, and the head of Museum Zoologicum Bogoriense - LIPI, Ibu Lilick Prijono, for their assistance in Jakarta and Bogor. Dr Djoko Iskandar assisted in many ways in the field, and I am most grateful for his input to this project. This research was part of Conservation International's Rapid Assessment Program, and I greatly appreciate their assistance. Funding support was provided by the CI-USAID Cooperative Agreement # PCE-5554-A-00-4028-00. I am especially grateful to Andy Mack, Yatna Supriatna, and Burke Burnett of CI for support during the survey, and to Mike Moore who helped collect. P.T. Freeport Indonesia provided logistical support for which I am most grateful. Mike Tyler commented on the manuscript and Bronwen Scott produced Fig. 1. Andy Mack helped produce the map.

LITERATURE CITED

HAAS, A. & RICHARDS, S.J. 1998. The correlation of cranial morphology, ecology and evolution in suctorial tadpoles of the Australian genera *Litoria* and *Nyctimystes* (Amphibia: Anura: Hylidae: Pelodryadinae) Journal of Morphology 238: 109-141.

MACK, A. & ALONSO, L. (eds) 2000. A biological assessment of the Wapoga river area of northwestern Irian Jaya, Indonesia. RAP Bulletin of BiologicalAssessment 14. (Conservation International: Washington).

MENZIES, J.I. 1993. Systematics of *Litoria iris* (Anura: Hylidae) and its allies in New Guinea and a note on sexual dimorphism in the group. Australian Journal of Zoology 41: 225-255.

TYLER, M.J. 1968. Papuan hylid frogs of the genus *Hyla*. Zoologische Verhandelingen 96: 1-203.

TYLER, M.J. & DAVIES, M. 1978. Species-groups within the Australopapuan hylid frog genus *Litoria* Tschudi. Australian Journal of Zoology (supplement 63): 1-47.